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Imaging transitions in consciousness: Neural correlates of lucid dreaming

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Introduction

Common categorizations of consciousness distinguish between basal and higher-order aspects of this multifaceted concept [1]. Basal consciousness comprises perceptions and sensations, whereas higher-order consciousness constitutes reflections on these perceptions. In REM sleep, ordinary dreaming comprises only basal aspects of consciousness, while higher-order consciousness seems to be bound to wakefulness. However, the phenomenon of lucid dreaming is characterized by full-blown consciousness, including all higher-order aspects: The dreamer is able to reflect on his state of consciousness and realizes that he is dreaming [2]. Using a combined fMRI/EEG approach, we could reveal neural activity related to the genesis of higher-order consciousness by contrasting ordinary REM sleep with physiologically verified lucid REM sleep.

Methods

Four experienced lucid dreamers repeatedly slept in the MRI scanner under concurrent polysomnographic monitoring. They were instructed to communicate the state of lucidity by quick left-right-left-right (LRLR) eye movements that create an unambiguous pattern on the EOG (Fig. 1). Imaging data (GE Signa 1.5 T, 25 slices, FOV 22x22, TR 2s, TE 40ms) were recorded in continuous data acquisition of up to 22 min with continuous sleep EEG recordings (Brain Amp Systems, 32 channels including EOG and EMG). After postprocessing, data derived from the EOG (LRLR eye movements, Fig. 1) was utilized to mark the short periods of lucidity within unambiguous REM sleep.

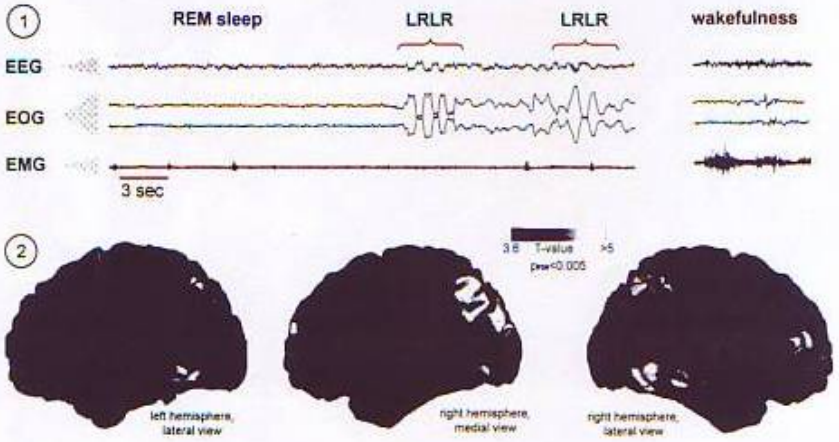

Fig. 1: The lucidity signal in the polysomnographic recording.

Fig. 2: Activity related to higher-order consciousness.

Results

Increased activation was observed in a range of neo-cortical regions, including bilateral precuneus, cuneus and parietal, prefrontal and occipito-temporal cortices (Fig. 2).

Discussion

Precuneus and frontopolar activation have been repeatedly associated with self-referential processing [4], while the fronto-parietal network activation might be a correlate of working memory demands. Activation in the bilateral cuneus and occipitotemporal cortices overlaps with the ventral stream of visual processing.

Increased activity was found in right dorsolateral prefrontal cortex, which is normally deactivated in REM sleep – something associated with the bizarre characteristics of normal dream thought [5].

Seen as a network, the regions activated during lucidity comprise substantial parts of the frontoparietal control system, which has been postulated to integrate information coming from other networks [3]. Interestingly, cerebral regions showing increased activity also show extensive expansion in humans as compared to non-human primates [6], providing neuroanatomical evidence for the hypothesis that the presence of higher-order consciousness is richest in humans [1].

Literature:
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